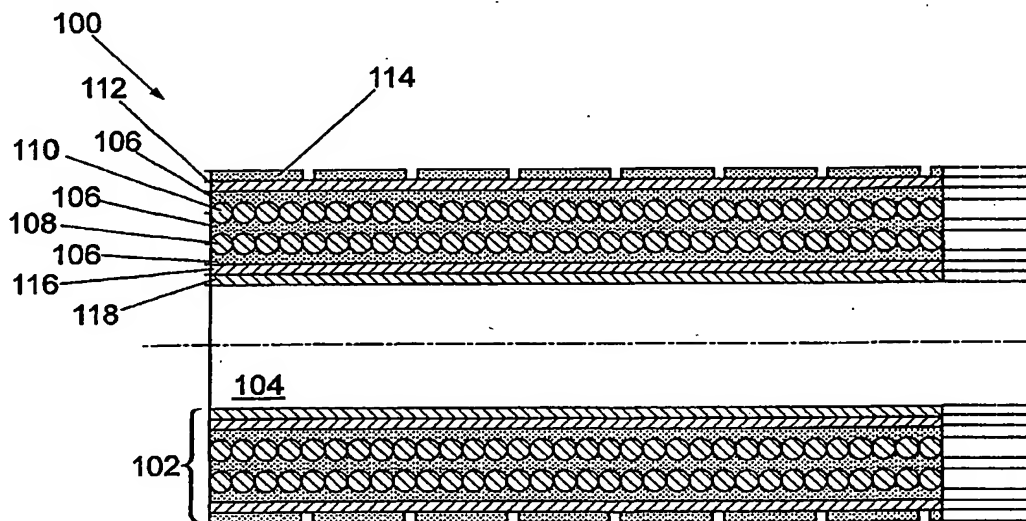


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(71)(72) Applicant and Inventor: DIXON-ROCHE, Keith [GB/GB]; 215 Old Dover Road, Canterbury, Kent CT1 3ER (GB).			
(74) Agent: PACITTI, Paolo ; Murgitroyd & Company, 373 Scotland Street, Glasgow G5 8QA (GB).			

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(57) Abstract

A hose or flexible pipe (100; 200) which has an inner lining (116; 216) composed of fluoropolymer. This gives the hose an improved capacity to withstand high temperatures, chemical degradation, and embrittlement along with flexibility and light weight. The hose wall structure (102) is preferably fully bonded to improve support for the fluoropolymer lining (116; 216). The fluoropolymer lining (116; 216) also makes practicable the use of rubbers having the ability to withstand high temperatures. There is also described an assembly of such a hose or flexible pipe (100; 200) with an end fitting (300 + 400; 310 + 410) incorporating a novel pressure-actuated seal (500, 502; 600; 800).

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1 **"HOSES OR FLEXIBLE PIPES"**

2

3 This invention relates to hoses or flexible pipes, and
4 relates more particularly but not exclusively to hoses
5 or flexible pipes which are adapted to the transport of
6 hydrocarbons.

7

8 As used in this specification, the terms "hose" and
9 "flexible pipe" are mutually synonymous. A hose (or
10 flexible pipe) is an elongate flexible tube suitable
11 for the transport of fluids (liquids and/or gases), and
12 which can adapt to different paths without permanent
13 deformation, eg. to provide a fluid path between
14 objects which are in relative movement, such as a
15 floating tanker and a production platform anchored on
16 the sea bed. Hydrocarbons produced by undersea wells
17 are frequently chemically and physically aggressive,
18 and hence liable to cause unacceptable damage to
19 transport hoses. Hoses usually require end fittings by
20 which the hose ends may be mechanically anchored and
21 also secured in a fluid-tight manner to a source or
22 receiver of the fluid to be transported by the hose.
23 Such end fittings require to be reliably sealed to the
24 hose both to withstand pressure and to withstand
25 degradation by the fluid transported by the hose.

26

1 According to a first aspect of the present invention
2 there is provided a hose or flexible pipe characterised
3 in that the hose or flexible pipe is internally lined
4 with an internal lining comprising a fluoropolymer.

5
6 The hose or flexible pipe is preferably formed such
7 that the wall of the hose or flexible pipe is a bonded
8 structure at least in the part of the wall contacted by
9 the internal lining. The wall of the hose or flexible
10 pipe is preferably a fully bonded structure.

11
12 The fluoropolymer of the internal lining is preferably
13 at least one fluoropolymer selected from the group of
14 fluoropolymers comprising ETFE (ethyl-tetra-fluoro-
15 ethylene), FEP (fluorinated ethylene propylene), HFP
16 (hexa-fluoro-propylene), and PFA (per-fluoro-alkozyl).

17
18 The hose or flexible pipe may comprise reinforcement
19 means which is preferably embedded in the wall of the
20 hose or flexible pipe. The reinforcement means
21 preferably comprises at least one reinforcement
22 selected from the group of reinforcements comprising at
23 least two layers of steel wire helically wound around
24 and along the hose or flexible pipe, or at least one
25 layer of synthetic polymeric textile material which may
26 comprise aramid fibres. The reinforcement means may be
27 embedded in an elastomer which may comprise silicone
28 rubber, the elastomer preferably being reinforced by
29 embedded yarn.

30
31 The internal lining of the hose or flexible pipe may
32 itself be internally lined with an collapse-resistant
33 liner which may be in the form of a self-interlocking
34 spiral of steel strip.

35
36 According to a second aspect of the present invention

1 there is provided a pressure-actuated seal for sealing
2 the interface between an end fitting mounted on and
3 secured to an end of a hose or flexible pipe and the
4 internal lining of the hose or flexible pipe,
5 characterised in that the seal comprises at least one
6 cavity in the end fitting, the or each said cavity
7 being contiguous with the interface, and in that a
8 respective mass of polymeric material is located in the
9 or each said cavity to be adjacent the interface,
10 wherein the or each said cavity communicates with the
11 bore of the hose or flexible pipe to transfer the
12 pressure of fluid in the bore of the hose or flexible
13 pipe to the respective mass of polymeric material such
14 as to urge the respective mass of polymeric material
15 against the portion of internal lining defining that
16 part of the interface with which the respective cavity
17 is contiguous.

18
19 The seal may comprise discrete communication means for
20 communicating the or each said cavity with the bore of
21 the hose or flexible pipe. The discrete communication
22 means may comprise fluid passage means, and where there
23 are a plurality of cavities in the end fitting, the
24 fluid passage means may lead from a given cavity either
25 directly to the bore of the hose or flexible pipe, or
26 indirectly by way of another cavity which itself is
27 directly or indirectly communicated with the bore of
28 the hose or flexible pipe by way of a further fluid
29 passage means.

30
31 At least one cavity in the end fitting may extend
32 circumferentially around the fitting, and the
33 respective mass of polymeric material located in said
34 circumferentially extended cavity may be generally

35

36

1 toroidal. The or each generally toroidal mass of
2 polymeric material may incorporate a respective
3 reinforcing member which is itself generally toroidally
4 and preferably embedded in the respective mass of
5 polymeric material.

6
7 The polymeric material of the seal means is preferably
8 a fluoropolymer which may be a fluoropolymer selected
9 from the group of polymers comprising ETFE (ethyl-
10 tetra-fluoro-ethylene), PTFE (poly-tetra-fluoro-
11 ethylene), FEP (fluorinated ethylene propylene), HFP
12 (hexa-fluoro-propylene) and PFA (per-fluoro-alkozyl),
13 or a mixture of two or more fluoropolymers selected
14 from said group of fluoropolymers.

15
16 In the seal means, the or each said mass of polymeric
17 material may be associated with a respective non-
18 polymeric member disposed between at least the greater
19 part of the respective mass and the inlet or inlets to
20 the respective cavity of the fluid passage means. The
21 or each said non-polymeric member may be formed of
22 sheet metal and be present in or on the respective mass
23 of polymeric material at least in the portion or
24 portions thereof adjacent said inlet or inlets.

25
26 Embodiments of the invention will now be described by
27 way of example, with reference to the accompanying
28 drawings wherein:

29 Fig. 1 is a longitudinal diametral section of a
30 first embodiment of hose;

31 Fig. 2 is a longitudinal diametral section of a
32 second embodiment of hose;

33 Fig. 3 is a fragmentary longitudinal diametral
34 section, to a much-enlarged scale, of part of the end
35 of the first embodiment of hose which is in the process
36 of having an end fitting secured and sealed thereto;

1 Fig. 4 is a perspective view of a seal forming
2 part of the arrangement illustrated in Fig.3;

3 Fig. 5 is a transverse cross-section of the seal
4 illustrated in Fig. 4;

5 Fig. 6 is a longitudinal diametral section of a
6 second arrangement of hose end, and fitting, and seal;

7 Fig. 7 is a longitudinal diametral section of an
8 inner part of the end fitting of Fig. 6 being prepared
9 to receive a seal;

10 Fig. 8 is a view corresponding to Fig. 7 and
11 illustrating the transfer moulding of the seal in the
12 inner part of the end fitting;

13 Fig. 9 is a longitudinal diametral section of a
14 third arrangement of hose end, end fitting, and seal;

15 Fig. 10 is a longitudinal diametral section of an
16 inner part of the end fitting of Fig. 9 being prepared
17 to receive a seal; and

18 Fig. 11 is a view corresponding to Fig. 10 and
19 illustrating the transfer moulding of the seal in the
20 inner part of the end fitting.

21
22 Referring first to Fig. 1, a first embodiment of hose
23 in accordance with the invention is represented by a
24 hose 100 having a tubular wall 102 surrounding a bore
25 104. The structure of the hose wall 102 is fully
26 bonded and comprises a layer 106 of silicone rubber
27 incorporating yarn as a reinforcement. Embedded in the
28 rubber layer 106 are two layers 108 and 110 of
29 reinforcement, each reinforcement layer 108, 110
30 comprising a respective steel wire spirally wound
31 around and along the hose 100.

32
33 The hose 100 is sheathed in an outer layer 112 of
34 rubber, such as chloroprene or Hypalon. The hose 100
35 optionally has an outer cover 114 of shrink-fitted
36 plastics which is perforated to release gases

1 permeating through the hose wall 102 from the bore 104.

2

3 The hose 100 is internally lined with an internal
4 lining 116 composed of a suitable fluoropolymer, such
5 as ETFE (ethyl-tetra-fluoro-ethylene), FEP (fluorinated
6 ethylene propylene), HFP (hexa-fluoro-propylene), or
7 PFA (per-fluoro-alkozyl). The lining 116 may be
8 composed of other suitable fluoropolymers, or a mixture
9 of two or more fluoropolymers.

10

11 The internal lining 116 is optionally lined with an
12 abrasion-resistant layer or barrier 118 of any suitable
13 material, for example a self-interlocking spiral of
14 steel strip.

15

16 Various advantages arise from the use of a
17 fluoropolymer as an internal lining material for a
18 hydrocarbon transport hose:

19 (a) unlike other plastics, fluoropolymers do not
20 blister due to gas-induced explosive
21 decomposition;

22 (b) unlike other plastics, fluoropolymers do not
23 require plasticisers which may be leached out by
24 hot dry gases transported through the hose to
25 leave the lining embrittled. As a hose-lining
26 material, fluoropolymers are typically ten times
27 more flexible than the rubbers previously
28 employed as hose-lining materials;

29 (c) fluoropolymers are highly impermeable to gas,
30 typically having one-tenth of the gas permeability
31 of the rubbers previously employed as hose-lining
32 materials;

33 (d) as hose-lining materials, fluoropolymers can
34 be utilised at much higher temperatures than other
35 plastics;

36 (e) fluoropolymers are the flexible materials most

1 chemically resistant to crude oil and associated
2 gases while being practicable for large-scale use.

3
4 Referring now to Fig. 2, this illustrates a second
5 embodiment of hose in accordance with the invention,
6 comprising a hose 200 having a tubular wall 202
7 surrounding a bore 204. The structure of the hose wall
8 202 is generally similar to the structure of the hose
9 wall 102 previously described in respect of the first
10 embodiment of hose 100, namely yarn-reinforced rubber
11 206 externally sheathed in a rubber layer 112 with an
12 optional outer layer 214 of perforated plastics, an
13 internal lining 216 of fluoropolymer which may be the
14 same fluoropolymer (or mix of fluoropolymers) as
15 utilised for the internal lining 116 of the first
16 embodiment 100, and an optional innermost abrasion-
17 resistant lining 218 of self-interlocking spiral metal
18 strip.

19
20 The second embodiment of hose 200 differs from the
21 first embodiment of hose 100 in that the layers 108 and
22 110 of spirally-wound steel wire reinforcement are
23 replaced by respective layers 208 and 210 of aramid
24 textile embedded on the rubber 206 to serve as a two-
25 layer reinforcement of the hose 200.

26
27 In the second form of hose 200, the fluoropolymer inner
28 lining 216 serves the same function as the
29 fluoropolymer lining 116 in the first form of hose 100,
30 with the same advantages.

31
32 In both the first and second forms of hose 100 and 200,
33 their fully bonded wall structures have the advantage
34 of providing continuous support for the fluoropolymer
35 inner lining, since fluoropolymers tend to cold flow
36 under pressure and therefore non-bonded hose wall

1 structures cause difficulty in providing adequate
2 support for fluoropolymer linings. If it is necessary
3 or desirable for at least part of the wall structure of
4 a hose in accordance with the invention to be non-
5 bonded, then at least those parts of the wall structure
6 adjacent the inner lining should nevertheless be bonded
7 or otherwise formed to provide substantially continuous
8 support for the fluoropolymer lining. Fully bonded
9 hoses and flexible pipes are preferred since bonded
10 hoses and flexible pipes are generally cheaper to
11 manufacture, lighter in weight per unit length, and
12 more flexible than non-bonded hoses and flexible pipes.

13
14 The use of heat-resistant fluoropolymers as inner
15 linings in bonded hoses and flexible pipes permits the
16 use in the bonded hose walls of rubbers which are
17 resistant to high temperatures to match the higher
18 temperature resistance of fluoropolymers, specifically
19 rubbers which are more heat resistant than materials
20 previously used in hoses (wherein the use of rubber
21 which was resistant to high temperature was irrelevant
22 and unnecessarily expensive in the absence of a
23 matching heat resistance for whatever lining material
24 was employed). Thus bonded hoses with fluoropolymer
25 linings in accordance with the invention can transport
26 fluids containing gases at high temperature and high
27 pressure but without the risk of delamination or
28 degradation inherent in prior art hoses. In
29 particular, a bonded hose with fluoropolymer lining can
30 withstand up to 200°C (which is 70°C hotter than any
31 prior art hose can withstand for an indefinite time),
32 while being considerably lighter and more flexible than
33 prior art hoses.

34
35 Referring now to Fig. 3, this illustrates in diametral
36 longitudinal section and to a much-enlarged scale, part

1 of the end of the hose 100 (equivalent to the upper
2 left corner of Fig. 1) and parts 300 and 400 of an end
3 fitting about to be secured to the end of the hose 100.
4 The end fitting is initially in two parts, namely a
5 suitably profiled inner sleeve 300 and a suitably
6 profiled outer sleeve 400 which are placed respectively
7 inside and outside the hose end (as depicted in Fig. 3)
8 so as partly to penetrate/overlie the hose end, with
9 portions of each fitting part (leftwards of the
10 portions shown in Fig. 3 and not themselves shown in
11 Fig. 3) remaining beyond the end of the hose 100. (End
12 fittings which are similar but not identical are shown
13 more completely in Figs. 6 and 9 to which reference may
14 be made to comprehend the context of Fig. 3).
15

16 To assist in proper attachment of the end fitting,
17 certain layers of the hose wall 102 are cut back as
18 shown in Fig. 3. The outer plastics cover 114 is
19 substantially completely removed from the portion of
20 the hose end which is to lie within the end fitting,
21 and the abrasion-resistant self-interlocked spiral 118
22 is cut back for about half the distance by which the
23 hose end will penetrate the end fitting. Of the
24 essential bonded structure of the hose wall 102, the
25 rubber sheath 112, the fluoropolymer lining 116, and
26 portions of the rubber layer 106 radially inside the
27 reinforcement layer 108 and radially outside the
28 reinforcement layer 110 are stripped for about one-
29 quarter of the depth of penetration of the hose into
30 the end fitting. This leaves the reinforcement layers
31 108 and 110, together with as much of the rubber 106 as
32 was sandwiched between the layers 108 and 110, not cut
33 away (save for possible preliminary tidying of the very
34 end of the hose to remove any excessive raggedness).
35

36 When the sleeves 300 and 400 are suitably located on

1 the pre-trimmed end of the hose 100 as shown in Fig. 3,
2 the sleeve portions sandwiching the hose end are swaged
3 onto the hose end so as to compress and permanently
4 entrap the hose, the rightward end of the inner fitting
5 part 300 being radially expanded and the rightward end
6 of the outer fitting part 400 being radially
7 compressed. When swaging is complete, the sleeves 300
8 and 400 are welded together at points remote from the
9 hose 100, or otherwise suitably mutually secured, and
10 thereby formed (together with any other necessary
11 fitting parts) into a unitary end fitting by which the
12 hose 100 can be mechanically anchored and coupled in a
13 fluid-tight manner to a source or receiver of fluids to
14 be transported by the hose.

15
16 Although end fittings which are swaged onto
17 conventional hoses are usually adequately leak tight,
18 the more extreme conditions under which hoses of the
19 present invention are utilised present additional
20 problems of sealing, aggravated by the tendency of the
21 fluoropolymer inner lining to cold flow. To counteract
22 such problems, and to ensure reliable sealing between
23 the hose and its end fitting, the arrangement shown in
24 Fig. 3 incorporates a pair of active seals which will
25 now be described in detail.

26
27 Referring again to Fig. 3, the sealing of the end
28 fitting 300 and 400 to the hose 100 is based upon a
29 primary active seal 500 and a secondary active seal
30 502. The primary and secondary seals 500 and 502 have
31 mutually identical structures of a generally toroidal
32 shape, but operate under different conditions (as will
33 be detailed subsequently). Details of an individual
34 one of the seals 500 and 502 will be given below with
35 reference to Figs. 4 and 5.

36

1 The primary active seal 500 is lodged in a cavity 504
2 having the form of a circumferential groove machined
3 into the periphery of the inner end fitting part 300
4 where that part will form an interface with the hose in
5 the fully assembled end fitting. The cavity or groove
6 504 has a width in the longitudinal direction of the
7 fitting part 300 (horizontally in Fig. 3) which is
8 slightly greater than the overall axial length of the
9 seal 500. The groove 504 has a depth in the radial
10 direction of the fitting part 300 (vertically in Fig.
11 3) which is somewhat less than the radial dimension of
12 the seal 500 in its relaxed condition (ie radial extent
13 from inner to outer faces in the absence of external
14 forces), but marginally greater than the radial
15 dimension of the seal 500 in its bound condition (ie
16 radial extent from inner to outer faces when radially
17 compressed just sufficiently to collapse an internal
18 gap which will subsequently be detailed with reference
19 to Figs. 4 and 5). Thus the cavity 504, when bound by
20 the adjacent portion of the lining 116 with which the
21 fitting part 300 and the cavity 504 form an interface,
22 holds the seal 500 in a condition in which it is
23 neither radially relaxed nor radially closed up.

24
25 The cavity 504 is linked by three spaced-apart
26 drillings 506 (only one of which is visible in Fig. 3)
27 to the vicinity of the anti-abrasion lining 118 and
28 thence to the fluid in the hose bore 104 by way of the
29 inter-turn gaps in the spiral strip layer 118. Thus
30 the cavity 504 and at one side of the seal 500 (the
31 right side of the cavity 504 as viewed in Fig. 3) is
32 exposed to whatever pressure prevails in the hose bore
33 104.

34
35 The secondary active seal 502 (which is structurally
36 and dimensionally identical to the seal 500) is lodged

1 in a cavity 508 in the form of a circumferential groove
2 which is dimensionally identical to the cavity or
3 groove 508, the cavity 508 being also formed in the
4 periphery of the inner part 300 of the end fitting but
5 axially further away from the end of the fitting which
6 leads into the hose bore 104. The cavity 508 is linked
7 at one side (the right side as viewed in Fig. 3) by
8 three spaced-apart drillings 510 (only one of which is
9 visible in Fig. 3) to one side of the cavity 504 (the
10 left side as viewed in Fig. 3) at locations which are
11 each separated by the seal 500 from the inlets to the
12 cavity 504 from the drillings 506 (these inlets being
13 at the right side of the cavity 504 as viewed in
14 Fig. 3). Thus, whereas one side of the primary active
15 seal 500 (the right side as viewed in Fig. 3) is
16 exposed to the full pressure in the hose bore 104, the
17 corresponding side of the secondary active seal 502
18 (also the right side as viewed in Fig. 3) is exposed
19 only to the pressure of whatever leaks past the seal
20 500. This difference in types of pressure to which the
21 seals 500 and 502 are respectively exposed gives rise
22 to their functional differences, as denoted by the
23 terms "primary" and "secondary" respectively. The term
24 "active" also applied to both seals 500 and 502 arises
25 from structure of these seals which causes the outer
26 half of each seal to tend to expand radially outwards
27 when exposed to a pressure differential axially across
28 the seal, as will now be described in detail with
29 reference to Figs. 4 and 5.

30
31 Fig. 4 is a perspective view of a complete one of the
32 seals 500 or 502, while Fig. 5 is a transverse cross-
33 section of the seal 500 (or 502) taken on the line V-V
34 in Fig. 4 and presented to an enlarged scale with
35 respect to the scale of Fig. 4. The seal 500 is
36 generally toroidal (Fig. 4) with a cross-section which

1 is externally a near-rectangular trapezoid (Fig. 5)
2 when relaxed (i.e. free of external forces). Most
3 significantly, the seal 500 has a cross-section which
4 is approximately U-shaped, having a longitudinally
5 extending inner part 520, and a longitudinally
6 extending outer part 522, these parts 520 and 522 being
7 mutually coupled at one axial end of the seal by a
8 radially extending part 524. The parts 520, 522, and
9 524 are not mutually distinct since the seal 500 is
10 integrally formed, and reference is made to different
11 parts of the seal only to facilitate the functional
12 description which follows.

13
14 The seal 500 contains a U-shaped titanium strip 526
15 (Fig. 5) around which a fluoropolymer is moulded,
16 except for a slot 528 extending along the centre of the
17 U-shaped strip 526. The slot 528 is open to one end
18 face of the seal 500 (the left end as shown in Fig. 5
19 and the right end as shown in Fig. 3), and thereby
20 defines the three seal parts 520, 522, and 524.

21
22 Reverting to Fig. 3, the seals 500 and 502 are placed
23 in their respective cavities or grooves 504 and 508
24 prior to the inner sleeve 300 of the end fitting being
25 offered up to the end of the hose 100. When the end
26 fitting is assembled and swaged on the end of the hose,
27 with the seals 500 and 502 in place as indicated in
28 Fig. 3, and the hose bore 104 is pressurised with a
29 fluid to be transported through the hose 100, the fluid
30 passes through the interstices of the spiral strip
31 winding constituting the layer 118 and through the
32 drillings 506 to pressurise the right side (as viewed
33 in Fig. 3) of the cavity 504. Because the seal 500 is
34 located in the cavity 504 with the open end of its slot
35 528 in the right side of the cavity 504, the
36 pressurisation of right side of the cavity 504 and the

1 consequent pressurisation of the slot 528 tends to open
2 up to the seal 500, i.e. to cause the seal's outer part
3 524 to tend to expand radially outwards and into firmer
4 contact with the inner lining 116 of the hose 100.
5 (The inner part 520 of the seal 500 is constrained from
6 moving radially inwards by the underlying body of the
7 sleeve 300). The seal 500 is thereby pressure-
8 actuated, i.e. its sealing effect is augmented from
9 whatever sealing is effected in the absence of pressure
10 differentials, to some higher level of sealing which
11 level is a function of the pressure to be sealed.

12

13 To the extent that imperfections of sealing permit
14 fluid to pass the primary seal 500, such leakage into
15 the left side of the cavity 504 (as viewed in Fig. 3)
16 will transfer an increase in pressurisation via the
17 drillings 510 to the right side of the secondary seal
18 502, and thereby cause pressure-actuation of the seal
19 502 to bring it into effect as a backup to the primary
20 seal 500. The structure and function of the secondary
21 seal 502 are the same as for the primary seal 500, with
22 the only substantive differences between these seals
23 being in their respective locations and sources of
24 pressurisation.

25

26 Fig. 6 shows another arrangement of hose end, end
27 fitting, and active seal, this other arrangement being
28 similar in principle to the arrangement of Fig. 3, but
29 different in detail. As with the previous end fitting,
30 in the arrangement of Fig. 6, the end fitting is
31 initially in two parts, namely a suitable profiled
32 inner sleeve 310 and a suitably profiled outer sleeve
33 410 which are placed respectively inside and outside
34 the end of the hose 100. In the Fig. 6 arrangement,
35 the inner sleeve 310 is sealed to the inner lining 116
36 of the hose 100 by an active seal 600 of generally

1 toroidal form. The seal 600 is formed from a
2 fluoropolymer of suitable properties and may be one of
3 the fluoropolymers from which the inner lining 116 is
4 selected, or a mixture of such fluoropolymers. The
5 seal 600 is located in a cavity having the form of a
6 circumferential groove 602 in the peripheral face of
7 the inner sleeve 310. Because the cavity or groove 602
8 is cut inwards from the periphery of the sleeve 310 at
9 a portion of the sleeve 310 which is inside the hose
10 bore 104 and in contact with the inner lining 116, the
11 cavity 602 is contiguous with the interface between the
12 inner lining 116 and the inner sleeve 310 of the end
13 fitting. The cross-section of the cavity 602 is
14 tapered towards the mouth of the cavity from a bi-
15 angularly convex radially inner surface, somewhat
16 resembling a tip-truncated arrow head. Several spaced-
17 apart passages 604 extend from the radially inner
18 surface of the cavity 602 radially inwards through the
19 body of the inner sleeve so as to communicate the
20 cavity 602 radially inwards of the seal 600 with the
21 continuation of the hose bore 104 through the end
22 fitting. The centre of the bi-angularly convex floor
23 is capped by a circumferentially expandable toroidal
24 strip 606 of metal which serves to transmit fluid
25 pressure (arriving by way of the passages 604 from the
26 hose bore 104) to the radially inner side of the seal
27 600, and thereby pressure-actuate the seal 600 radially
28 outwards into sealing contact with the inner lining 116
29 of the hose 100.

30

31 A preferred method of forming the seal 600 will now be
32 described with reference to Figs. 7 and 8.

33

34 Fig. 7 shows the first stage in forming the seal 600.
35 The inner sleeve 310 of the end fitting is initially
36 separate from the outer sleeve 410, and remote from the

1 hose 100. The periphery of the sleeve 310 is formed
2 with the circumferential cavity or groove 602, and the
3 radial passages 604 are drilled or otherwise formed
4 between the radially inner surface of the cavity 602
5 and the bore of the sleeve 310. The toroidal metal
6 strip 606 is then fitted onto the radially inner
7 surface of the cavity 602. The strip 606 may be formed
8 as (for example) a spring steel ring with a single
9 transverse slit so as to be circumferentially
10 expandable sufficiently to fit over the periphery of
11 the sleeve 310 and be slid along the sleeve until
12 springing into the cavity 602. Such capacity of the
13 strip 606 for circumferential expansion is also more
14 than adequate for the pressure-actuated expansion of
15 the seal 600 in the completed sealing arrangement.

16
17 Fig. 7 represents the preparatory stage for the second
18 stage of forming the seal 600, which will now be
19 described with reference to Fig. 8.

20
21 In Fig. 8, the Fig. 7 arrangement is fitted with a ring
22 mould 700 which is a close fit around the periphery of
23 the inner sleeve 310 in the region of the sleeve
24 periphery wherein the cavity or groove 602 is formed.
25 The inner face of the mould 700 is sealed to the sleeve
26 periphery on both axial sides of the cavity 602 by
27 means of in-built metallic O-rings 702. The mould 700
28 is radially aligned on the sleeve 310 by the close fit
29 of their inner and outer peripheries, respectively.
30 The mould 700 is axially aligned on the sleeve 310 by
31 means of an end plate 704 which abuts the end of the
32 sleeve 310 when the mould 700 is at its correct axial
33 location on the sleeve 310. Angular alignment of the
34 mould 700 on the sleeve 310 is not essential, since the
35 seal 600 eventually to be produced is circumferentially
36 uniform.

1 The ring mould 700 incorporates an injection nozzle 706
2 by which molten fluoropolymer from a separate extruder
3 (not shown) is injected into the cavity 602 so as to
4 transfer mould the seal 600 in situ. Since the
5 passages 604 are blocked against outflow from the
6 cavity 602 by the capping of these passages with the
7 strip 606, venting of gases and surplus polymer from
8 the cavity 602 is allowed for by the provision of one
9 or more suitably located sprue holes 706 through the
10 inner face of the mould 700. When the injected
11 fluoropolymer has coagulated to a sufficient extent,
12 the mould 700 is removed from the sleeve 310 and
13 unacceptable surface defects in the newly moulded seal
14 600 are rectified. Functioning of the seal 600 under
15 pressure-actuation may be tested after curing but prior
16 to installation of the sleeve 310 as part of an end
17 fitting.

18
19 Fig. 9 shows a further arrangement of hose end, end
20 fitting, and active seal, this further arrangement
21 being essentially similar to the arrangement of Fig. 6,
22 and differing principally in details of the active
23 seal. Compared to the seal 600 in Fig. 6, the cross-
24 section of the seal 800 in Fig. 9 is turned through 90°
25 and the taper of the seal 600 is modified to
26 parallelism in the seal 800. The bi-angularly convex
27 bottom surface of the cavity 602 is now one side (the
28 right side as viewed in Fig. 9) of the corresponding
29 cavity 802, but the correspondingly angled strip 806
30 remains on this convex surface. Whereas in Fig. 6 the
31 pressure transmitting fluid passages 604 extended
32 radially, in Fig. 9 the corresponding pressure
33 transmitting passages now extend axially in further
34 accordance with the 90° transform of the cross-
35 sectional structure of the seal 800 with respect of the
36 cross-sectional structure of the seal 600.

1 Figs 10 and 11 show stages in the transfer moulding of
2 the seal 800 which correspond exactly with Figs. 7
3 and 8.

4
5 Fig. 9 also shows an optimal modification in which a
6 secondary or backup seal 850 may be provided, with a
7 respective pressure-transferring passage (not shown)
8 leading into either the cavity 802 (such that the seal
9 850 is pressure-actuated by leakage past the seal 800)
10 or directly to the bore of the sleeve 310 (such that
11 rather than being a backup seal, the seal 850 is
12 pressure-actuated in parallel with the seal 800 but
13 seals in cascade).

14
15 Modification and variations of the above-described
16 embodiments are possible without departing from the
17 scope of the invention. For example, two or more seals
18 could be provided in the Fig. 6 arrangement instead of
19 the single seal shown. In any of the arrangements of
20 Figs. 3, 6 or 9, the hose 100 (as detailed in Fig.1)
21 could be substituted by the hose 200 (as detailed in
22 Fig. 2) or by any other hose having a fluoropolymer
23 lining in accordance with the invention. As already
24 mentioned, the hose layers 114 and 118 in the hose 100
25 (and the corresponding layers 214 and 218 in the hose
26 200) are optional, and other modifications can be
27 adopted such as (for example) providing a number of
28 reinforcing layers (108, 110; 208; 210) greater or
29 lesser than two or omitting discrete reinforcement
30 layers altogether (and relying on the yarn
31 reinforcements mixed in with the rubber of the layer
32 106 or 206). All forms of the pressure-actuated seal
33 so far described with reference to the drawings have
34 been toroidal and circumferentially continuous, but it
35 is conceivable that additional or alternative seals may
36 be required or desired for interface areas that are not

1 complete rings, and as such, the pressure-actuated
2 seals may be limited to discrete portions of the
3 interface which portions are not ring-like, the shape
4 of the sealing surface of the mass of seal material
5 being appropriately re-shaped from the illustrated ring
6 shapes.

7
8 Other modifications and variations of the
9 above-described exemplary embodiments can be adopted
10 without departing from the scope of the invention as
11 defined in the appended claims.
12

1 CLAIMS

2

3 1. A hose or flexible pipe (100; 200) characterised
4 in that the hose or flexible pipe (100; 200) is
5 internally lined with an internal lining (116;
6 216) comprising a fluoropolymer.

7

8 2. A hose or flexible pipe (100; 200) as claimed in
9 claim 1 characterised in that the wall (102; 202)
10 of the hose or flexible pipe (100; 200) is a bonded
11 structure at least in the part (106; 206) of the
12 wall (102; 200) contacted by the internal lining
13 (116; 216)

14

15 3. A hose or flexible pipe (100; 200) as claimed in
16 claim 2 characterised in that the wall (102; 202)
17 of the hose or flexible pipe (100; 202) is a fully
18 bonded structure.

19

20 4. A hose or flexible pipe (100; 200) as claimed in
21 any preceding claim characterised in that the
22 fluoropolymer of the internal lining (116; 216) is
23 at least one fluoropolymer selected from the group
24 of fluoropolymers comprising ETFE (ethyl-tetra-
25 fluoro-ethylene), FEP (fluorinated ethylene
26 propylene), HFP (hexa-fluoro-propylene), and PFA
27 (per-fluoro-alkozyl).

28

29 5. A hose or flexible pipe (100; 200) as claimed in
30 any preceding claim characterised in that the hose
31 or flexible pipe (100; 200) comprises
32 reinforcement means (108, 110; 208; 210) embedded
33 in the wall of the hose or flexible pipe (100;
34 200).

35

36 6. A hose or flexible pipe (100; 200) as claimed in

1 claim 5 characterised in that the reinforcement
2 means comprises at least one reinforcement
3 selected from the group of reinforcements
4 comprising at least two layers (108, 110) of steel
5 wire helically wound around and along the hose or
6 flexible pipe (100; 200), or at least one layer
7 (208, 210) of synthetic polymeric textile
8 material.

9
10 7. A hose or flexible pipe (100; 200) as claimed in
11 claim 6 characterised in that the synthetic
12 polymeric textile material comprises aramid
13 fibres.

14
15 8. A hose or flexible pipe (100; 200) as claimed in
16 any of claims 5, 6, or 7 characterised in that the
17 reinforcement means (108, 110; 208; 210) are
18 embedded in an elastomer (106; 206).

19
20 9. A hose or flexible pipe (100; 200) as claimed in
21 claim 8 characterised in that the elastomer (106;
22 206) is a silicone rubber.

23
24 10. A pipe or flexible hose (100; 200) as claimed in
25 claim 8 or claim 9 characterised in that the
26 elastomer (106; 206) is reinforced by embedded
27 yarn.

28
29 11. A hose or flexible pipe (100; 200) as claimed in
30 any preceding claim characterised in that the
31 internal lining of fluoropolymer (116; 216) is
32 itself internally lined with an collapse-resistant
33 lining (118; 218).

34
35 12. A hose or flexible pipe (100; 200) as claimed in
36 the claim 11 characterised in that the collapse-

1 resistant liner (118; 218) is in the form of a
2 self-interlocking spiral of steel strip.
3

4 13. A pressure-activated seal (500, 502; 600; 800) for
5 sealing the interface between an end fitting (300
6 + 400; 310 + 410) mounted on and secured to an end
7 of a hose or flexible pipe (100; 200) and an
8 internal lining (116; 216) of the hose or flexible
9 pipe (100; 200), characterised in that the seal
10 comprises at least one cavity (504, 508; 602; 802)
11 in the end fitting (300; 310), the or each said
12 cavity (504, 508; 602; 802) being contiguous with
13 the interface, and in that a respective mass of
14 polymeric material (500, 502; 600; 800) is located
15 in the or each said cavity (504, 508; 602; 802) to
16 be adjacent the interface, wherein the or each
17 said cavity (504, 508; 602; 802) communicates with
18 the bore (104; 204) of the hose or flexible pipe
19 (100; 200) to transfer the pressure of fluid in
20 the bore (104; 204) of the hose or flexible pipe
21 (100; 200) to the respective mass of polymeric
22 material (500, 502; 600; 800) such as to urge the
23 respective mass of polymeric material (500, 502;
24 600; 800) against the portion of the internal
25 lining (116; 216) defining that part of the
26 interface with which the respective cavity (504,
27 508; 602; 802) is contiguous.
28

29 14. A seal as claimed in claim 13 characterised in
30 that the seal comprises discrete communication
31 means for communicating the or each said cavity
32 (504, 508; 602; 802) with the bore (104; 204) of
33 the hose or flexible pipe (100; 200).
34

35 15. A seal as claimed in claim 14 characterised in
36 that the discrete communication means comprises

- 1 fluid passage means (506, 510; 604; 804).
2
- 3 16. A seal as claimed in claim 15 wherein there are a
4 plurality of cavities (504, 508) in the end
5 fitting (300), characterised in that either the
6 fluid passage means (506) leads from a given
7 cavity (504) directly to the bore (104) of the
8 hose or flexible pipe (100), or the fluid passage
9 means (510) leads from a given cavity (508)
10 indirectly to the bore (104) by way of another
11 cavity (502) which itself is directly or
12 indirectly communicated with the bore (104) by way
13 of a further fluid passage means (506).
14
- 15 17. A seal as claimed in any of claims 13-16
16 characterised in that at least one cavity (504,
17 508; 602; 802) in the end fitting (300; 310)
18 extends circumferentially around the fitting (300;
19 310), and in that the respective mass of polymeric
20 material (500, 502; 600; 800) located in said
21 circumferentially extended cavity (504, 508; 602;
22 802) is generally toroidal.
23
- 24 18. A seal as claimed in any of claims 13-17
25 characterised in that the polymeric material of
26 the seal is a fluoropolymer selected from the
27 groups of fluoropolymers comprising
28 ETFE (ethyl-tetra-fluoro-ethylene),
29 PTFE (poly-tetra-fluoro-ethylene),
30 FEP (fluorinated ethylene propylene),
31 HFP (hexa-fluoro-propylene), and
32 PFA (per-fluoro-alkozyl), or a mixture of two or
33 more fluoropolymers selected from said group of
34 fluoropolymers.
35
- 36 19. A seal as claimed in claim 15 or claim 16 or in

1 either of claims 17 or 18 as directly or
2 indirectly dependent on claim 15, characterised in
3 that the or each said mass of polymeric material
4 (500, 502; 600; 800) is associated with a
5 respective non-polymeric member (526; 606; 806)
6 disposed between at least the greater part of the
7 respective mass (500, 502; 600; 800) and the inlet
8 or inlets to the respective cavity (504, 508; 602;
9 802) of the fluid passage means (506, 510; 604;
10 804).

11
12 20. A seal as claimed in claim 19 characterised in
13 that the or each said non-polymeric member (526;
14 606; 806) is formed of sheet metal and is present
15 in or on the respective mass of polymeric material
16 (500, 502; 600; 800) at least in the portion or
17 portions thereof adjacent said inlet or inlets.
18

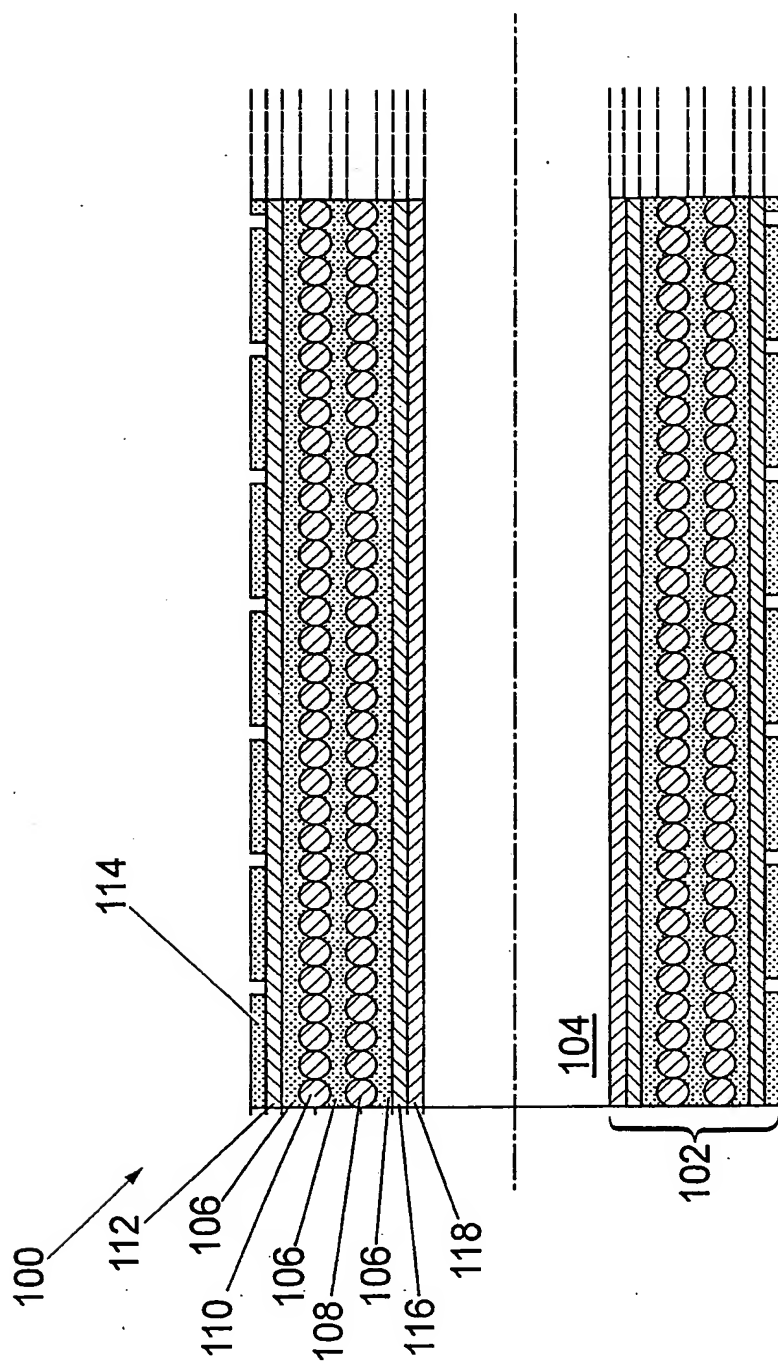


Fig. 1

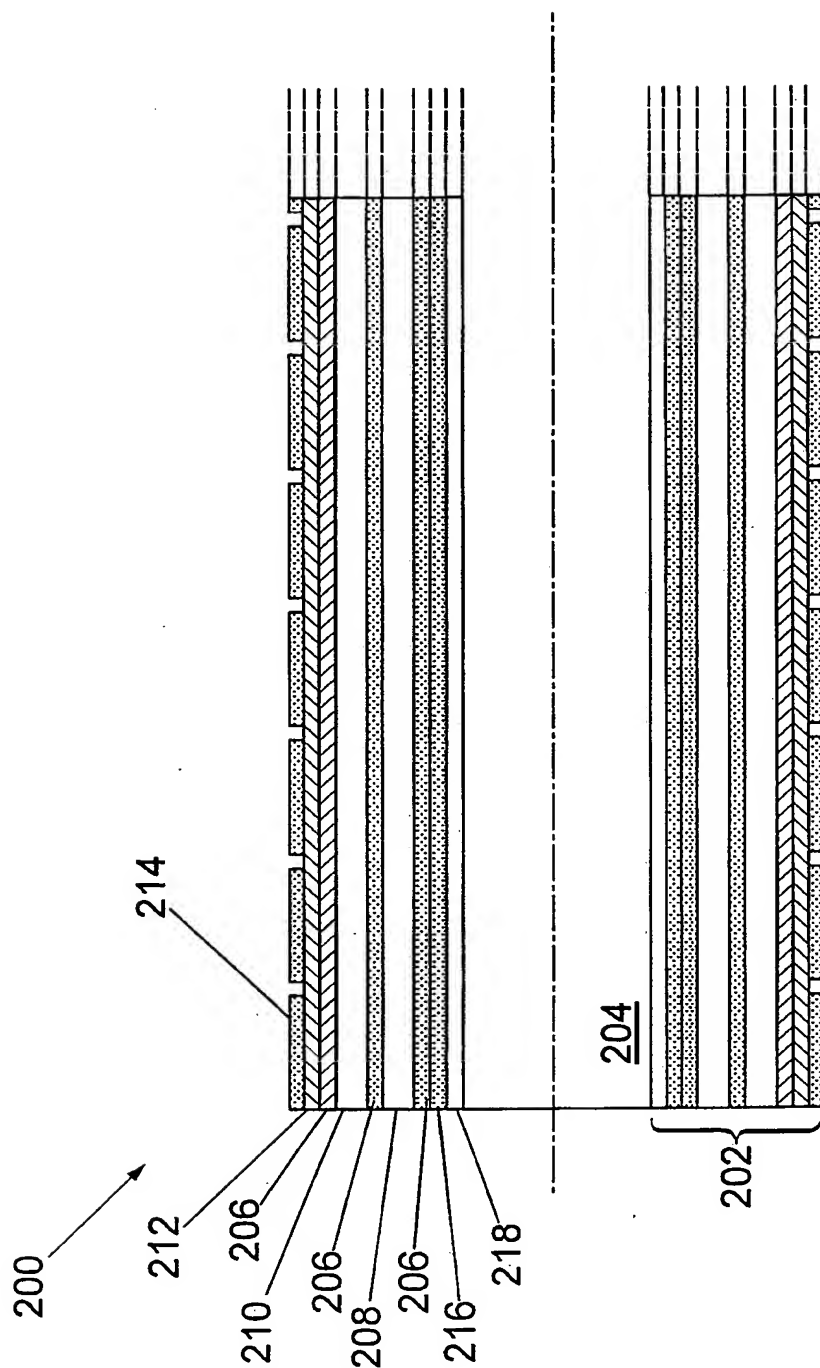


Fig. 2

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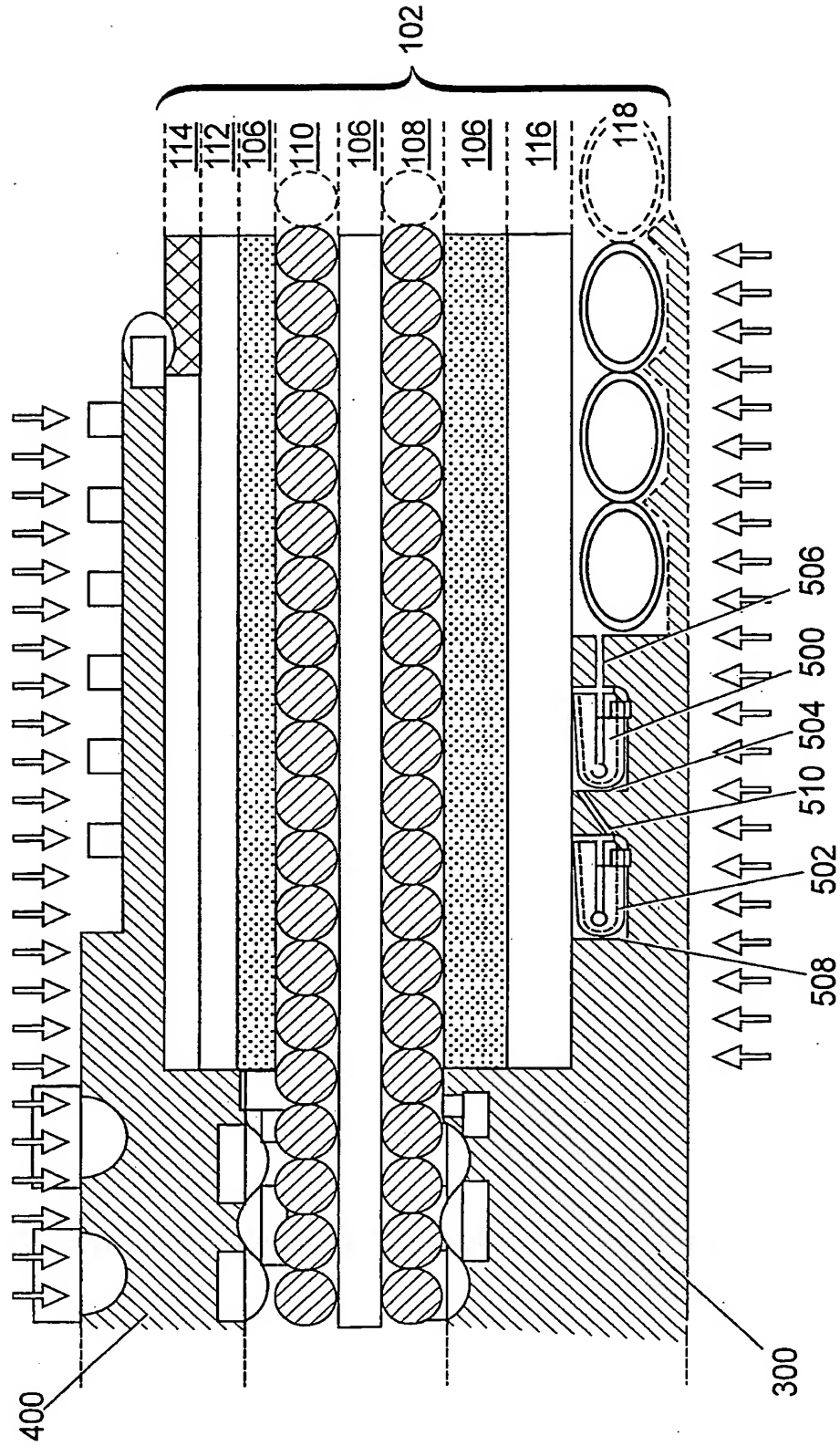


Fig. 3

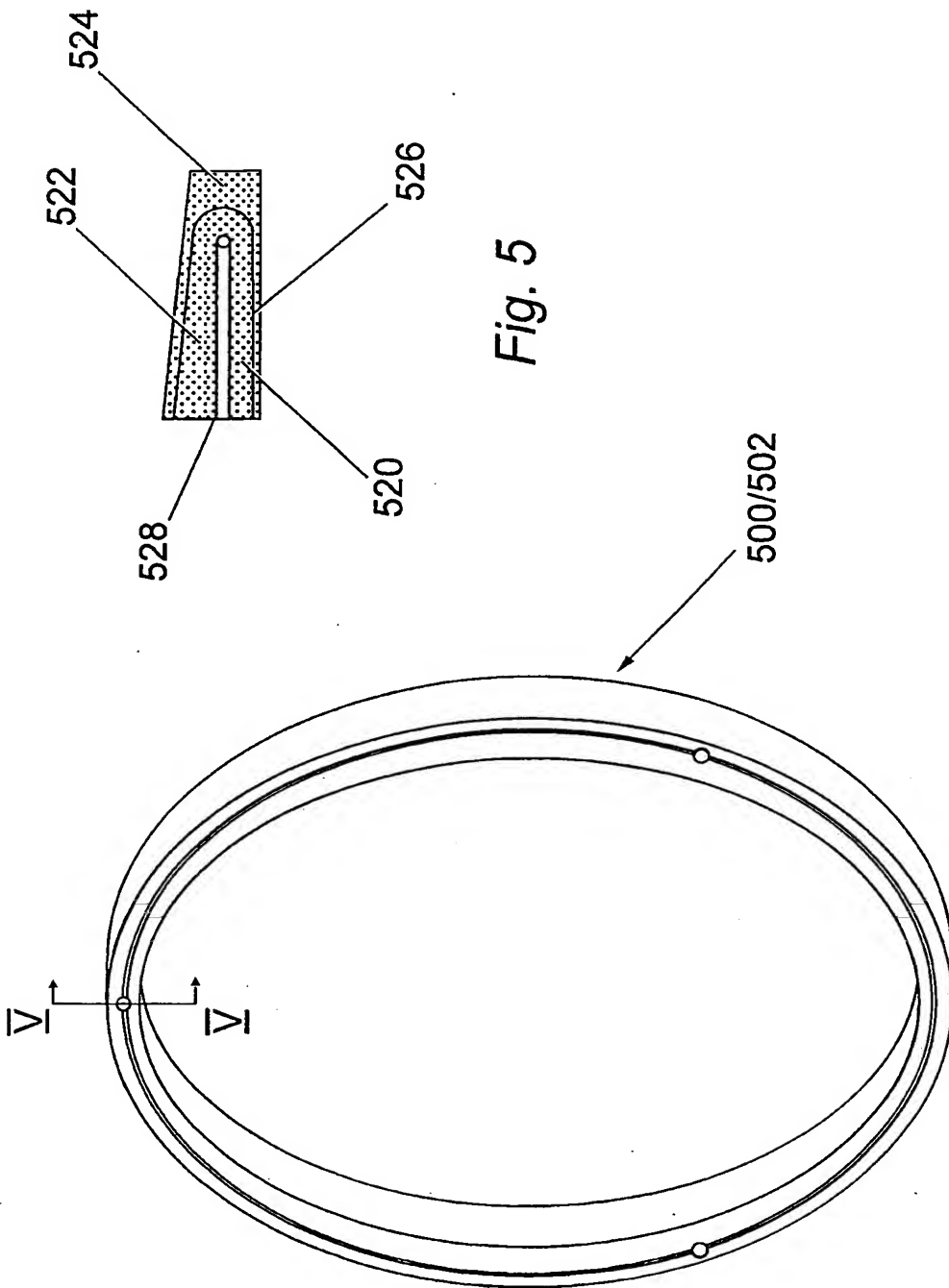


Fig. 5

Fig. 4

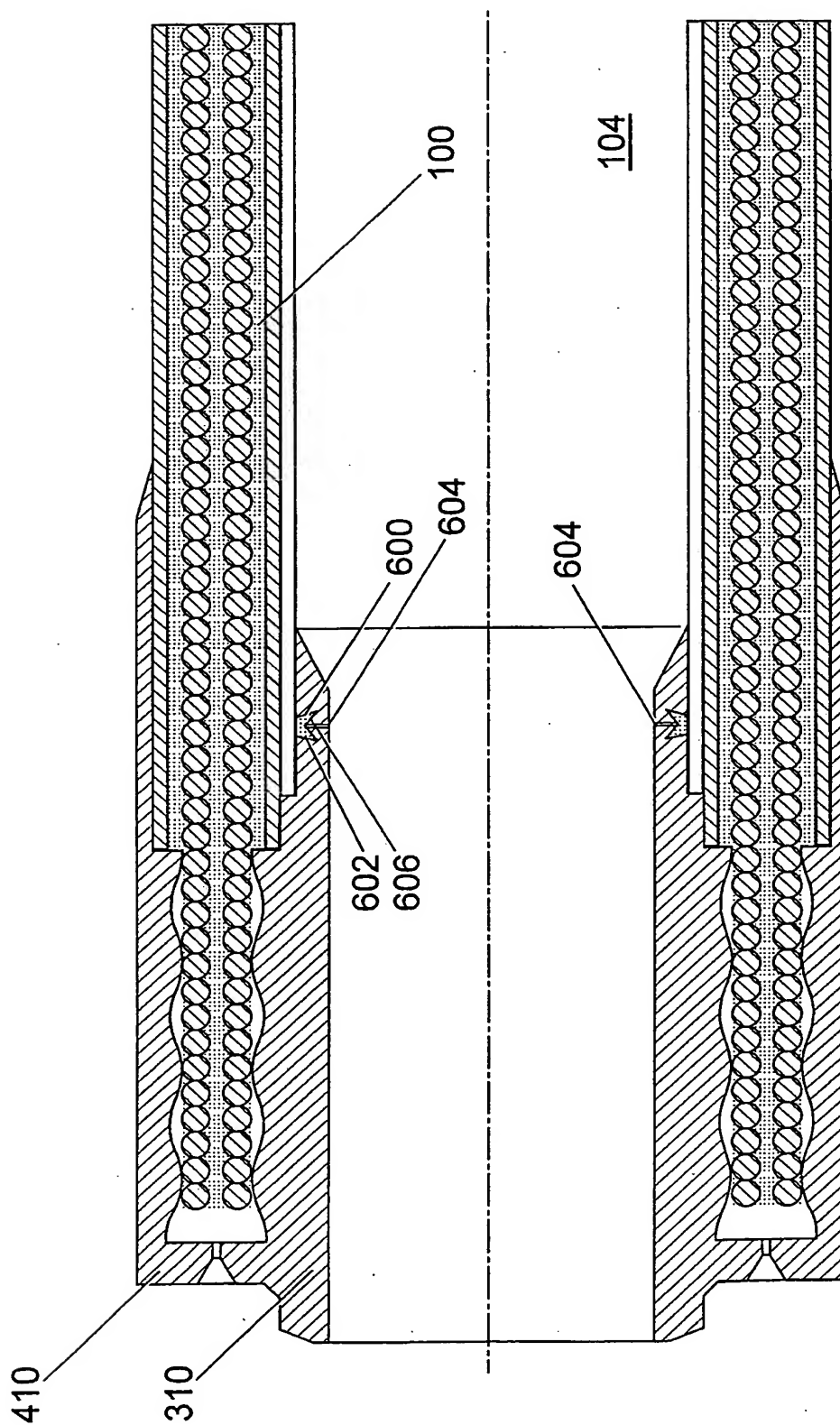


Fig. 6

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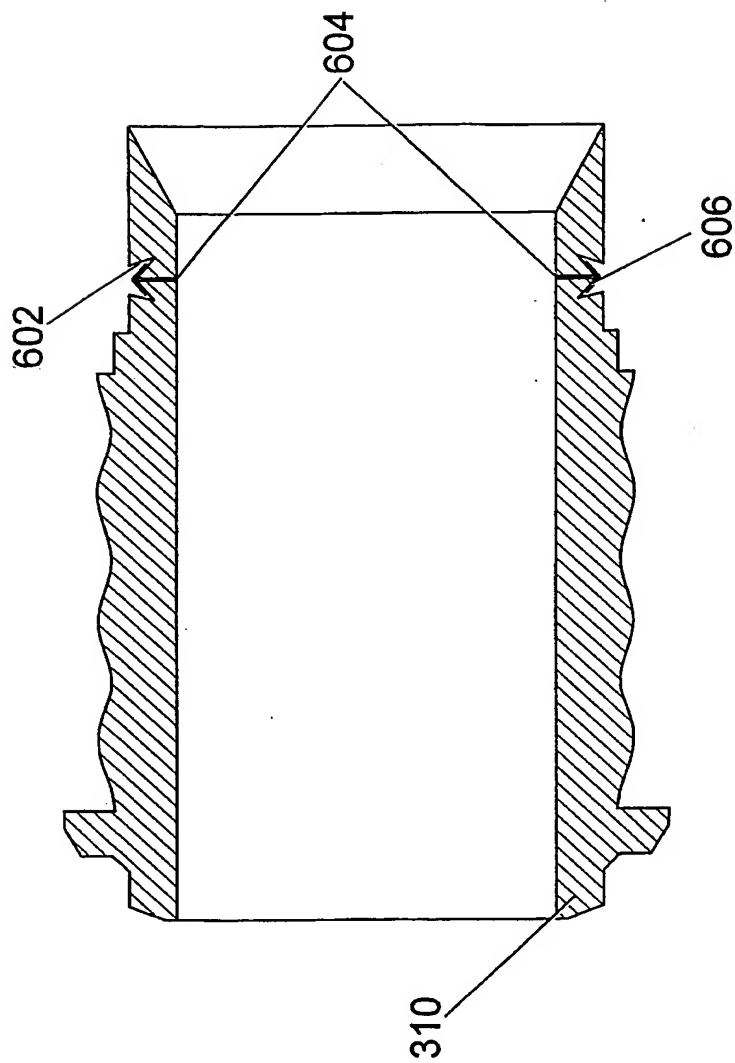


Fig. 7

7 / 10

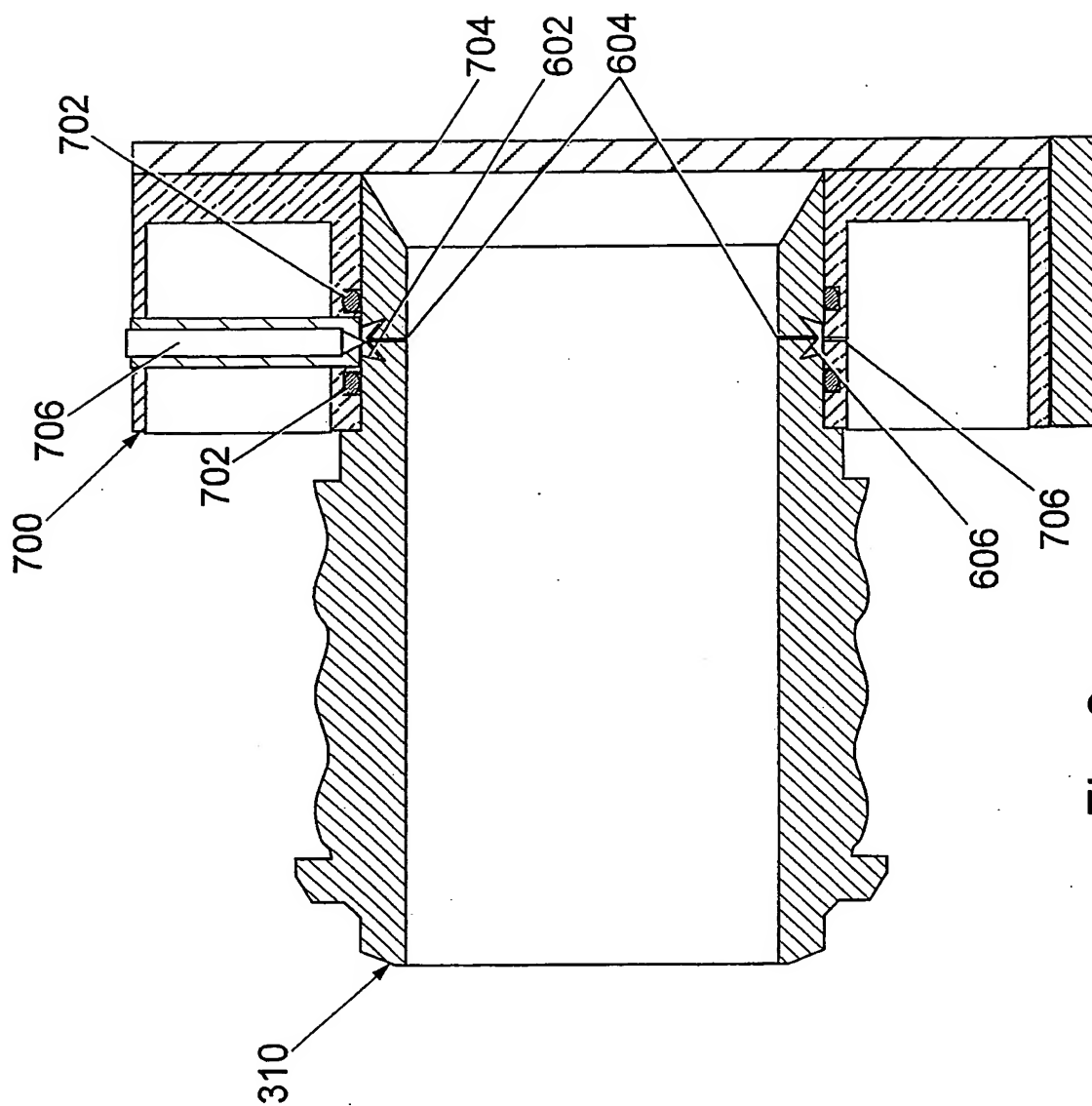


Fig. 8

8 / 10

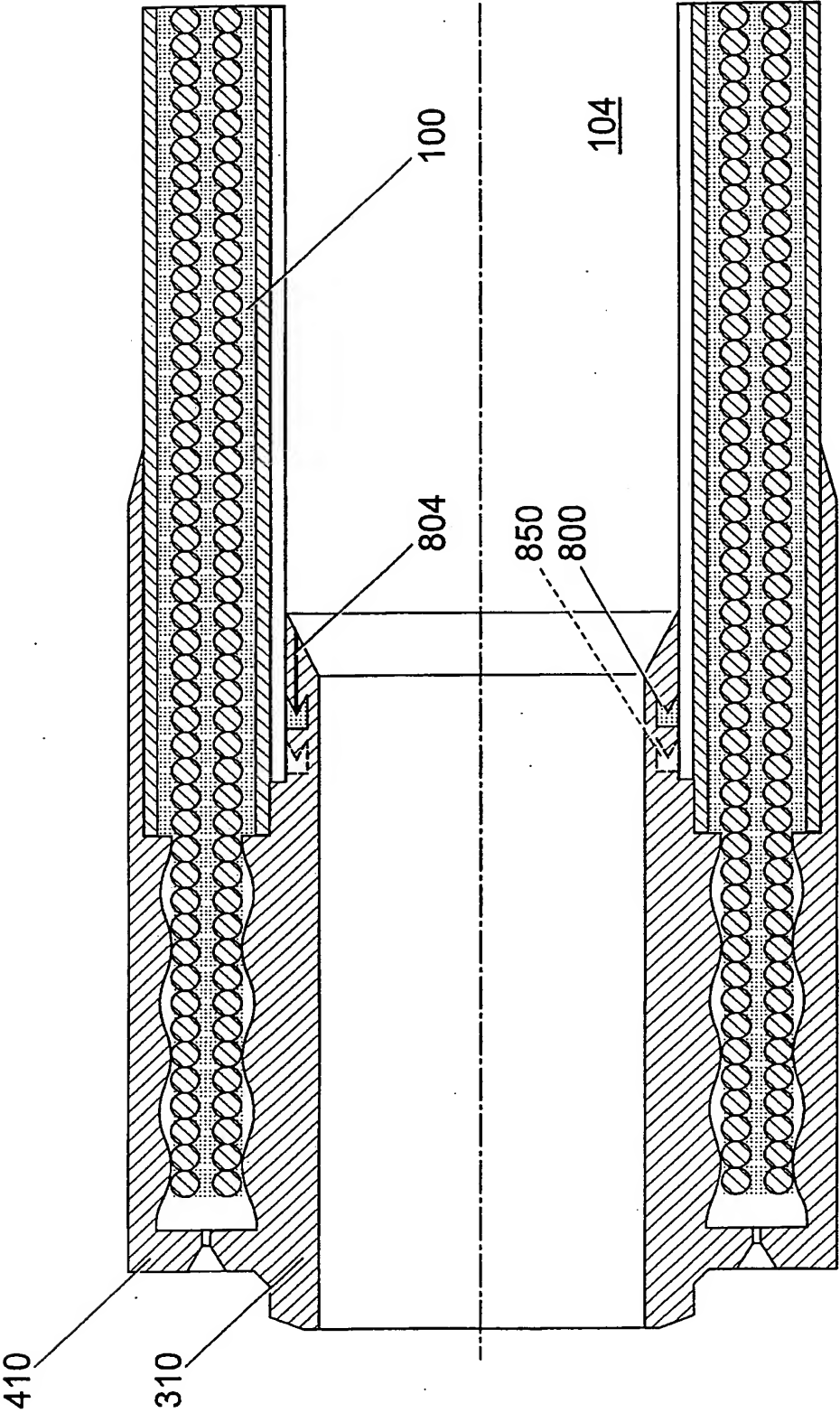


Fig. 9

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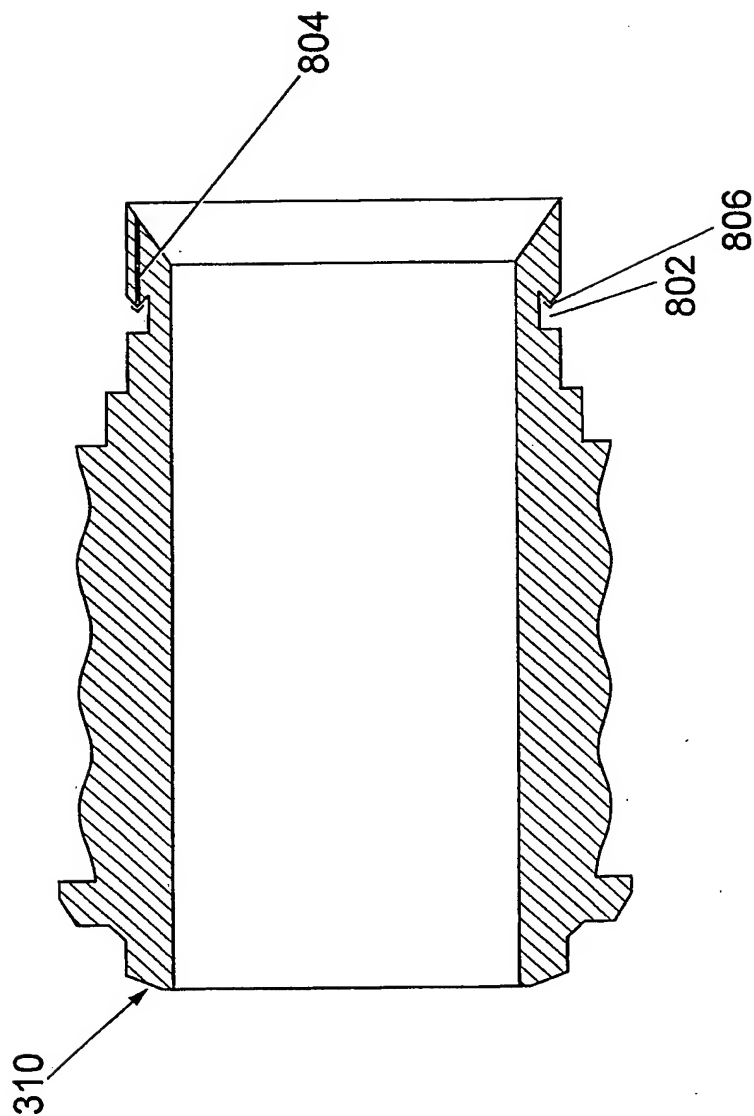


Fig. 10

10 / 10

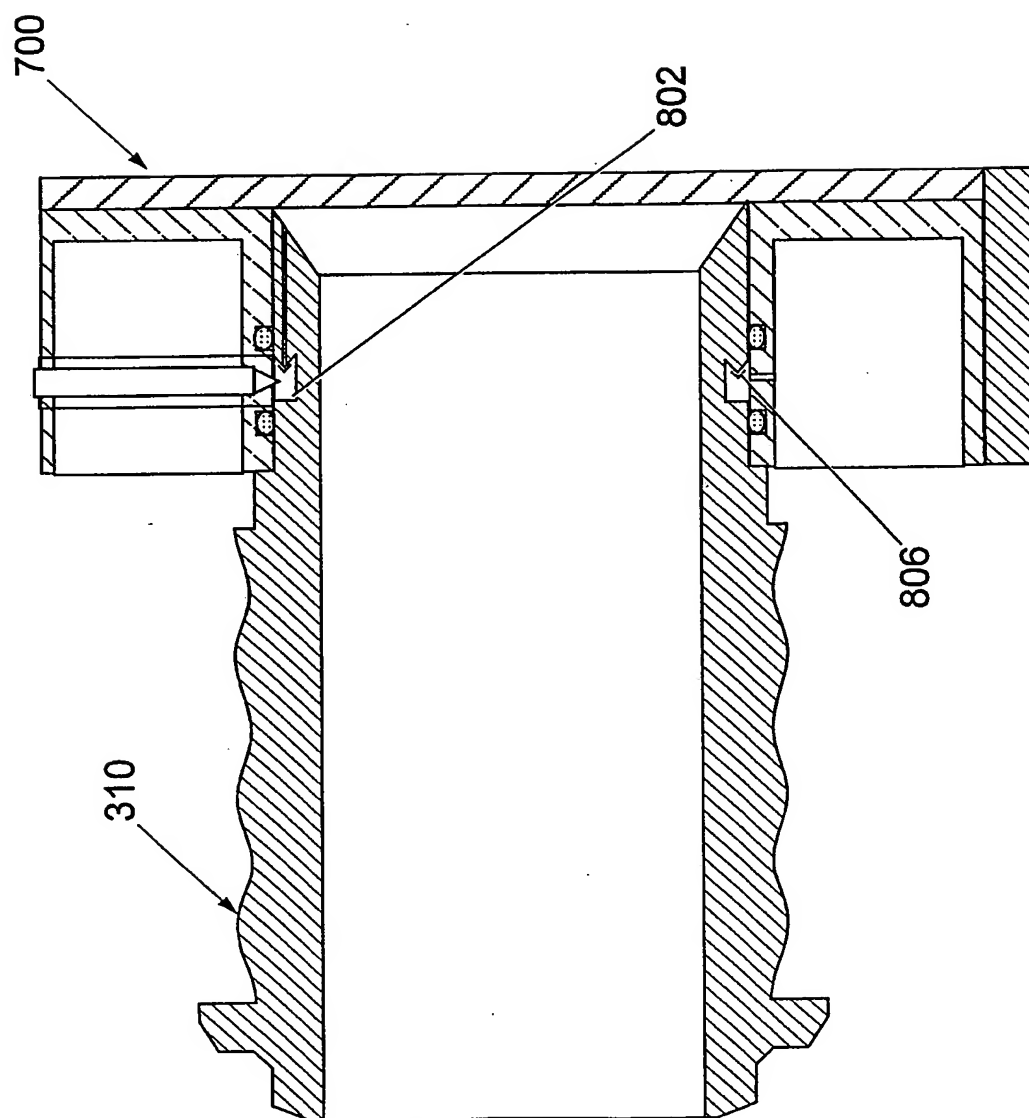


Fig. 11

INTERNATIONAL SEARCH REPORT

Intern. Application No
PCT/GB 98/03650

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F16L11/04 F16L11/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 F16L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 062 456 A (COOKE HORISE M ET AL) 5 November 1991 see claim 1; figure 1 ---	1-12
X	PATENT ABSTRACTS OF JAPAN vol. 015, no. 039 (M-1075), 30 January 1991 & JP 02 277633 A (TOYODA GOSEI CO LTD), 14 November 1990 see abstract ---	1-8,10
X	US 4 330 017 A (SATO SEIKOH ET AL) 18 May 1982 see claim 1 --- -/-	1-8,10

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
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- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- "&" document member of the same patent family

Date of the actual completion of the international search

5 February 1999

Date of mailing of the international search report

11.05.99

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Dupuis, J-L

INTERNATIONAL SEARCH REPORT

Inter. Application No
PCT/GB 98/03650

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 577 005 A (MAK MASCHINENBAU KRUPP) 5 January 1994 see column 2, line 35-46 - column 1, line 56; figure 1 ---	1,4-6
X	EP 0 582 302 A (TOKAI RUBBER IND LTD) 9 February 1994 see page 3, line 20-24; claim 1; figure 1 -----	1-4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB 98/03650

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-12

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

1. Claims: 1-12

hose or flexible pipe being internally lined with an
internal lining comprising a fluoropolymer

2. Claims: 13-20

a pressure activated seal for sealing the interface between
an end fitting mounted on and secured to an end of a hose or
flexible pipe

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 98/03650

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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